

The University of Chicago

THE RELATION OF THE KNEE JERK
AND STANDING STEADINESS TO
NERVOUS INSTABILITY

A PART OF THE DISSERTATION SUBMITTED
TO THE GRADUATE FACULTY IN CANDIDACY
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

By
MARY ALDEN MORGAN LEE

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THE RELATION OF THE KNEE JERK AND
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INSTABILITY

THE RELATION OF THE KNEE JERK AND STANDING STEADINESS TO NERVOUS INSTABILITY*

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THE question of the relationship of the knee jerk and standing steadiness or Romberg sign to "nervous instability" involves two distinct investigations; first as to the existence of demonstrable individual differences in these reflexes, and second as to the correlation of the reflexes with each other and with "nervousness" or "emotional instability" as indicated by such available criteria as ratings and questionnaire score.

The statement is often made in current neurological texts that the neurotic individual has exaggerated reflexes. A hyperactive knee jerk is given in clinical manuals as part of the diagnostic picture of neurasthenia. Another symptom said to be often found is a positive Romberg sign. Both of these tests, though relatively crude, are capable of yielding numerical scores which can be treated statistically. This, for the purpose of our study, gives them a marked advantage over the pharyngeal reflex which again is supposed to have distinct clinical significance. In contrast to the tendon reflexes, this is described as absent or depressed in "functional diseases of the nervous system". A few observations were made by us with this reflex and also with a salivary reflex.

By "nervous instability" we mean only, on the one hand, that which the Woodworth or Matthews questionnaire measures, and on the other, that which the layman means by the term. If there is no relation between these two meanings, no correlation should obtain between the scores, and if there is no agreement between laymen in the use of the term, this too should be obvious from the distribution of ratings. Although we cannot show from our data that the physician means by neurotic what the layman calls "nervousness" or the psychologist "emotional instability", it is surely the "nervous" child for whom advice is sought and the maladjusted adult who himself seeks advice. The clinician's diagnosis of neurasthenia is largely based on negative data: the absence of organic lesions; his positive data, if we exclude the

* This investigation was made at the University of Chicago under the direction of L. L. Thurstone. It also appears as a study from The Institute for Juvenile Research and it is listed with the Institute as Series B, No. 154.

debatable ground of reflexes which we are here attempting to study, is derived from such questions as the questionnaires incorporate, and from a rating based on a personal interview.

Much clarification of concepts in this field remains to be done. This investigation was undertaken merely with the hope of contributing a few general contour lines to a relatively uncharted area.

OUTLINE OF PROCEDURE

Apparatus and Experimental Technique.

The method used by us in obtaining and recording the knee jerk, standing steadiness and a salivary reflex has been described in full in our article on the effect of fasting.¹ The knee jerk was induced by an electrically driven hammer which was adjusted to deliver a blow of such force as would cause the least perceptible movement in a beam balance against one end of which it was placed at rest, counter-balanced by 430 gms. The patella tendon was struck perpendicularly at a spot one-third of the distance from its upper attachment. The subjects lay with eyes closed on a padded table and the blows were given in an irregular series of intervals varying from four to twenty-five seconds, to avoid the effect of expectancy and rhythm. The excursion of that part of the leg which was exactly seven inches below the table top was measured by means of a continuous tape on a modified myograph apparatus. The free pendulum-like swinging of the leg from the knee when raised by the experimenter or following a knee jerk was taken to be evidence of local relaxation and was present in all subjects when the experiment took place. At each test twenty knee jerks were recorded and the average of the four sums of five successive kicks each was taken as the subject's score.

Standing steadiness or the Romberg test was recorded graphically by means of a marker attached vertically to the subject's head. The latter stood in military position with heels together, toes slightly apart and eyes shut and was merely told to stand as still as possible for one minute. Two one-minute records were taken of the children and three of the adults. The sums of the greatest and least diameters of these tracings (which were not necessarily at right angles to each other nor parallel to the body planes) were determined, and their average taken as the day's score. A useful and time-saving modification of the method of recording devised by us was as follows. In place of a metal stylus attached to the head and writing on a smoked paper, there

¹ Lee, M. A. M., "The Effect of Fasting on the Knee Jerk and Standing Steadiness," *American J. Physiol.*, 1929, 90, 184-193.

was attached to the head band a loop of insulated wire of which only the terminal acute bend was exposed. By suitable heating of this wire electrically, it would trace a white line on a wax paper without burning the paper. The wax paper was easily fastened by thumb tacks to the horizontal board of adjustable height above the subject and could be quickly removed and filed as a permanent and non-bulky record.

The salivary reflex used depended upon the slight tendency to nausea or gagging caused by the presence in the mouth and across the posterior part of the tongue of a circle of twenty-four porcelain beads, three-fourths of an inch in diameter, strung on a flexible wire. The response recorded was the total salivary secretion during the first ten minutes that the beads were in the mouth. This was collected by means of a dentist's glass salivary ejector and controlled suction, and was measured in ccs.

In testing the pharyngeal reflex, the usual medical procedure was followed. The child being told to open his mouth widely, the posterior part of the tongue was gently held down by means of a tongue depressor, and the posterior wall of the pharynx was briefly touched by a long cotton-wrapped wooden applicator without touching the fauces. A physician's examination of throats becomes through practice highly automatized and probably changes little from subject to subject. However, techniques vary as well as subjective scales and for this reason and also to obviate errors in measurement due to individual differences in reaction to the personality of the experimenter, Dr. William Fishbein, the school physician, kindly ran the same test on all of the subjects. It was felt that agreement between the findings of the two different experimenters on different days would in this more or less subjective test be more significant than agreement between repeated tests by the same individual. The positive and negative scores include only those cases in which the reflex was definitely present or absent on both occasions; the intermediate group includes not only those in which the findings are in disagreement but those in which the reflex was found to be slight or doubtful.

Subjects and Plan of Experiments.

During the year of 1922 and 1923, a preliminary study was undertaken to determine the range of variability of the knee jerk and steadiness under standardized laboratory conditions. There were two subjects, a man and a woman, both research students in physiology. The tests were given daily at the same hour each day and no variables were introduced except certain periods of

experimental insomnia and fasting, the findings of which have been previously reported.¹

Experiment 1, conducted in February and March, 1928, is a study of ten medical school students selected as exhibiting different degrees of nervousness according to the ratings of their classmates. The ninety-three members of the second year class in medical school were asked independently to divide the students whom they knew in the class into five groups, from "one" (most nervously excitable or unstable) to "five" (most phlegmatic). Sixty-three students were rated by more than twenty judges. The average rank given each was calculated and the average deviation from that rank. Eleven were selected who had an A.D. of less than .6. One of these refused to serve as subject in the experiment. As there was greater agreement in regard to the students rated nervous than those rated phlegmatic, those with an average rating of four or five had large average deviations and so were not included in this group. The range of ratings was 1.1 to 3.2 in the ten chosen as subjects. The score of these on the Woodworth questionnaire was also obtained. The tests used were the knee jerk, standing steadiness, and a salivary reflex. They were obtained over a period of four weeks at different hours of the day as chance dictated without any attempt being made to avoid such variations in activities or worries as are incidental to ordinary daily life.

Experiment 2 (March to June, 1928) is a more extensive study of 258 children in the third, fourth, fifth, and sixth grades of the elementary school of the University of Chicago. Two tests, a week apart, were given to each child, one in the morning and the other in the afternoon, but with the exact hours subject to variation. The children were independently rated by three to five teachers as to their "nervousness". After the rating and without warning that it would be required, the teacher was asked to indicate in the case of each child judged nervous, upon what her judgment was based. A year later, 151 of these children were given the Matthews revision of the Woodworth questionnaire.

RESULTS AND DISCUSSION

Preliminary Study.

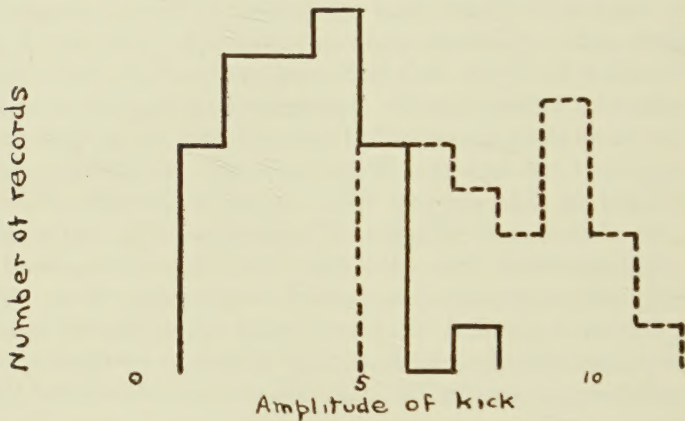
The daily records of the knee jerk of the two subjects during November and December, 1922, show that both subjects varied considerably from day to day, but that these variations tend to be confined within narrow limits. Subject Ha at this time had

¹ Lee, M. A. M., and Kleitman, N., "II. Studies on the Physiology of Sleep," *American J. Physiol.*, 1923, 67, 141-151.

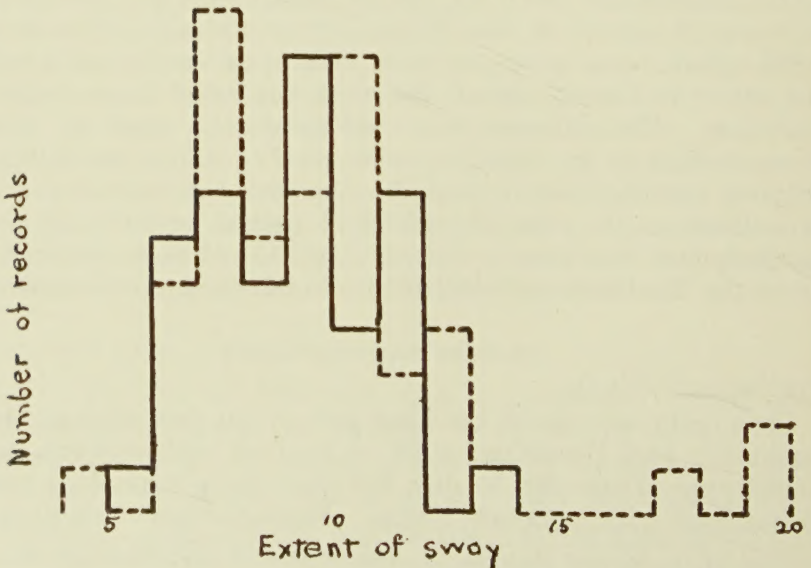
a consistently higher knee jerk than subject K. This is indicated by the superimposed histograms of both subjects showing the distribution of their records during this period (Figure 1-a). These limits are exceeded only in a period of five days fasting in both Ha and K and the menstrual period in Ha.

FIGURE 1
DISTRIBUTION OF DAILY RECORDS OF K (—) AND HA (---)
With fasting, insomnia and menstrual periods omitted.

a. KNEE JERK RECORDS
(10 determinations each day)



b. ROMBERG TEST
(3 one-minute trials daily)



As it proved impossible to keep our room at a constant temperature level, the curve of variation of temperature in the second half of the test period was compared with the variations in the knee jerk records. In some cases a sudden rise in the temperature produced a decrease in the knee jerk of both subjects, and a fall an increase. In fact these are the only cases in which the variation in the two records are coincident and in the same direction. We may conclude, therefore, that whenever there was an environmental cause of the variations operative, temperature was an index or partial component of it.

There can be no doubt that a true individual difference between K and Ha in the knee jerk existed during the months tested, a difference that far exceeded the variations due to objective or subjective causes, and for these months a measure of the knee jerk expressing its range of variation and central tendency can be said to be characteristic of the individual. That it may not be characteristic of these subjects a few months later we are equally confident, for at the end of December the knee jerk experiment was discontinued until May and it was then found that the knee jerk of K had so greatly decreased as to be barely obtainable without using some method of augmentation. The knee jerk of Ha, on the other hand, was approximately unchanged. The relevance of the fact that K was working under considerable strain at this time in preparation for his doctorate examination is, of course, debatable.

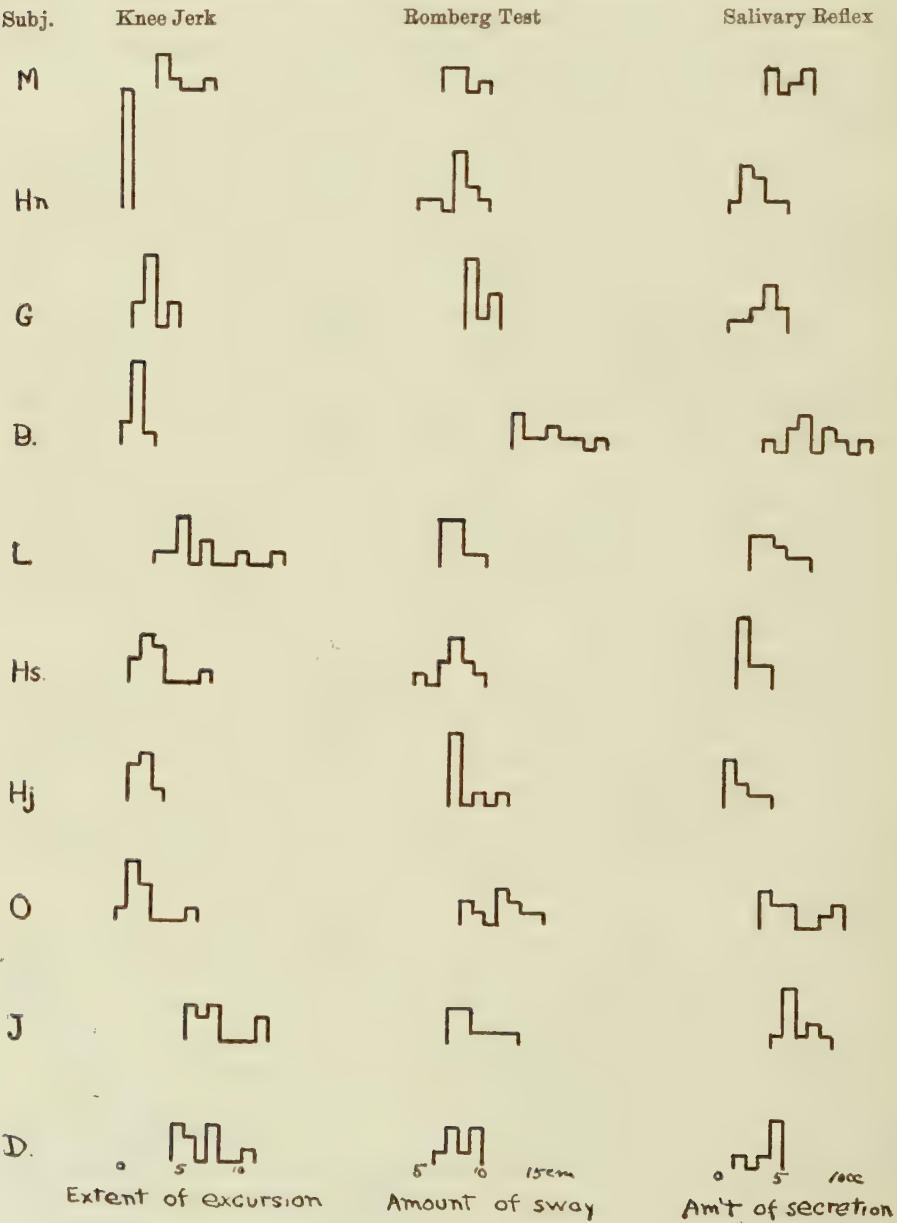
The steadiness records of these two individuals were not obtained the same year and there is no clear difference between the histograms of the two individuals (Figure 1-b). We can only say that over the periods tested, the two individuals produced rather closely similar pictures. As in the knee jerk, however, the relatively restricted range of variation, except during periods of experimental insomnia, seems a rather clearly established finding.

Experiment 1.

The ten measurements of the ten subjects in the three tests show, as in the preliminary study, a tendency for the individual to present a typical picture which differentiates him from other subjects in spite of the fact that the tests were conducted at different times of the day and under various conditions of fatigue or mood such as may occur in the ordinary course of existence. These very sources of variation which are usually eliminated as far as possible are here intentionally admitted and in spite of them there is a rather striking consistency in the records of an

individual. The distribution of the ten records in histograms for each test, shown in Figure 2, illustrates this point.

FIGURE 2
DISTRIBUTION OF RECORDS OF TEN SUBJECTS.



That there is some relationship between the three reflexes also seems to be indicated by the fact that the two individuals, B and O, who deviate the most from the group in unsteadiness in the Romberg test also have very low knee jerks and salivate the most actively in response to an uncomfortable mechanical stimulus in the mouth. This relationship, however, is not consistently present throughout the group as a whole. If we attempt to indicate the relations roughly by the method of rank differences, the possible significance of these extreme cases is concealed. The correlation between unsteadiness and salivation is .54, but between either of these and the knee jerk scores the correlations are only .15 and .17. If we compare, by the same crude statistical method, the scores in the reflexes with the criteria, we again find negligible values for r except in relation to the knee jerk. The amplitude of the latter has a correlation of .50 with nervous stability as determined by ratings and $-.69$ with neurotic tendencies as indicated by the questionnaire. The significance of these relationships depends, of course, upon the validity of our criteria. The latter seems to be indicated by the high correlation ($-.83$) between the ratings and the scores on the Woodworth questionnaire. This may be due in part to the high reliability of the ratings of the subjects chosen, and also to the probability that medical school students have opportunity to observe each other in conditions which involve more than usual stress—early days of dissecting and operating, laboratory emergencies as well as quizzes—and so have much upon which to base their judgments of nervous stability. Yet the validity of even these ratings is not beyond question as perhaps a brief analysis of the ten subjects may suggest.

M and Hn were short, extremely active individuals, walking and talking at a very rapid rate, never still. They both stated that they knew they gave the impression of being nervous but said they did not think they really were. The next two, G and B, on the other hand, felt themselves to be working under great strain. One reported extreme fatigue, frequent headache, and difficulty in digestion and sleeping; the other was maladjusted socially, and was continually engaged in self-analysis. The judgment of nervousness in L and Hs was apparently based on shyness and a tendency to blush easily. The identical rating and similar scores in the questionnaire of the two girls, however, presents a curious anomaly. Hj was socially adaptable, well-adjusted and popular. O, on the contrary, regarded it as a great joke that she had been able to fool the world. She told me "Folks that know me best say that I'm the most nervous person they ever saw." She spoke

TABLE I
AVERAGE SCORES OF TEN MEDICAL SCHOOL STUDENTS BASED ON TEN TESTS EACH

Subject	Rating	Questionnaire score	Amplitude of knee jerk	Extent of body sway in Romberg test	Amount of reflex salivation in 10 min.
M.	1.1 .17	24	3.42"	7.35 cm	5.38 cm
Hn	1.2 .34	21	0	7.26	2.78
G.	2.0 .45	32	1.75	9.36	2.92
B.	2.0 .58	35	0.64	14.90	6.94
L.	2.4 .59	12	4.07	7.46	3.82
Hs.	2.8 .51	13	2.17	7.41	2.15
Hj.	2.9 .48	12	1.23	8.44	1.41
O.	2.9 .57	17	1.22	11.27	5.71
J.	3.1 .50	11	7.52	8.78	6.12
D.	3.2 .47	2	6.61	8.14	3.90

INTERCORRELATIONS BY THE METHOD OF RANK DIFFERENCES

Rating of nervousness and questionnaire score*	r	— .83	.069
Rating of nervousness and amplitude of knee jerk	r	.50	.168
Rating of nervousness and unsteadiness	r	.36	.194
Rating of nervousness and salivary reflex	r	.07	.222
Questionnaire score and amplitude of knee jerk	r	— .69	.117
Questionnaire score and unsteadiness	r	.20	.214
Questionnaire score and salivary reflex	r	.18	.216
Amplitude of knee jerk and unsteadiness	r	.15	.218
Amplitude of knee jerk and salivary reflex	r	.17	.217
Unsteadiness and salivary reflex	r	.54	.158

* Nervousness is indicated by a low rating score and a high score in questionnaire.

of "holding on" to herself all of the time, of using all of her power "to keep control and keep calm". When unable to "stand it" any longer, she went home to her mother ("who can always help me") for three days and returned feeling more "relaxed" and "indifferent". On the day of her return, her knee jerk was markedly higher than on other days. One of the other subjects who had worked with her told me she was known as "little poker face" but when operating her hands shook so she had to stop work. We felt that the depressed knee jerk, the marked unsteadiness, the active salivation, as well as a depressed pharyngeal reflex, which placed her at the extreme end of our scale, were more reliable indices of her condition than either the questionnaire or the rating. This was amply proved six weeks later when the girl committed suicide. The two men at the low end of the rating (*i.e.*, having the largest rating score indicating stability) and questionnaire scores, one could hardly doubt were free from neurotic traits. D was a typical "extrovert". J was an intelligent, sensitive person who later had no difficulty in carrying on research which entailed the swallowing of a particularly large stomach balloon. This analysis is presented to show that while in the main our criteria are valid, they are both subject to serious error, and in this group of individuals, at least, they failed to differentiate as

the reflex measures did, the one who was unequal to the test of existence.

Experiment 2.

Two knee jerk records, based on twenty knee jerks each, were obtained a week apart from 254 children in the 3rd, 4th, 5th and 6th grades, and steadiness records based on two one-minute trials each were taken on 188 children in the 3rd, 4th, and 5th grades. Four children were examined on only one occasion in regard to the knee jerk and 70 were tested only once in steadiness. There is a correlation of .757 between the first and second knee jerk records and the two steadiness records correlate .702 with each other. (See Table II). This is in itself evidence that true individual differences exist, since if the spread of the records was a function only of the variability of the reflexes themselves, the correlation should be zero between the first and second series. Correcting these coefficients by Brown's formula, the reliability of the knee jerk test as given is .862 and the steadiness test has a reliability of .825.

A second proof of the existence of the individual differences consists in showing that the standard deviation of the true measurements in the reflexes is larger than the standard deviation of the chance errors. We are greatly indebted to Dr. L. L. Thurstone for the derivation of this proof which is as follows:

Let x be the true measure, and x_1 and x_2 the 1st and 2nd actual scores obtained.

Let σ be the standard deviation of the true measure, and σ_1 and σ_2 be the standard deviations of the obtained scores.

Let e_1 and e_2 be the variable errors in x_1 and x_2 .

Let E be the standard error in x_1 and x_2 (assumed to be the same in both cases) or in other words, E is the standard deviation of the variable errors e_1 .

$$\begin{aligned} x_1 &= x + e_1 \\ x_1^2 &= x^2 + 2xe_1 + e_1^2 \end{aligned}$$

But since e_1 is a chance error and as often positive as negative $2xe_1 = 0$.

$$\text{Therefore } x_1^2 = x^2 + e_1^2$$

$$\text{and } \Sigma x_1^2 = \Sigma x^2 + \Sigma e_1^2$$

$$\text{and } \frac{\Sigma x^2}{n} = \frac{\Sigma x^2}{n} + \frac{\Sigma e_1^2}{n}$$

$$\text{or } \sigma_1^2 = \sigma^2 + E^2$$

In order to isolate σ and E , we proceed as follows:

$$x_1 = x + e_1$$

$$x_2 = x + e_2$$

Subtracting we have

$$x_1 - x_2 = d = e_1 - e_2 \text{ or } d^2 = e_1^2 - 2e_1 e_2 + e_2^2$$

$$\text{but since } 2e_1 e_2 = 0, d^2 = e_1^2 + e_2^2$$

$$\text{and } \sqrt{\frac{\sum d^2}{n}} = \sqrt{\frac{\sum e_1^2}{n} + \frac{\sum e_2^2}{n}} = \sqrt{E_1^2 + E_2^2}$$

Let $\sigma_d = \sqrt{\frac{\sum d^2}{n}}$ the standard deviation of the differences between the first and second measurements of the same subjects. Then $\sigma_d^2 = E_1^2 + E_2^2$, and if we assume these to be equal $\sigma_d^2 = 2E^2$

$$\text{or } \sigma_d = E\sqrt{2} \text{ or } \frac{\sigma_d}{\sqrt{2}} = E$$

$$\text{Since } \sigma_1^2 = \sigma^2 + E^2, \sigma^2 = \sigma_1^2 - E^2$$

$$\text{and by analogy } \sigma^2 = \sigma_2^2 - E^2$$

$$\text{Adding these } 2\sigma^2 = \sigma_1^2 + \sigma_2^2 - 2E^2$$

$$\sigma^2 = \frac{\sigma_1^2 + \sigma_2^2}{2} - E = \frac{\sigma_1^2 + \sigma_2^2}{2} - \frac{\sigma_d^2}{2}$$

$$\sigma = \sqrt{\frac{\sigma_1^2 + \sigma_2^2}{2} - \frac{\sigma_d^2}{2}}$$

In our data the following values are obtained.

$$\text{Knee jerk } \sigma_1 = 4.508$$

$$\sigma_2 = 5.338$$

$$\sigma_d = 2.1485$$

$$E = 1.519$$

$$\sigma = 4.701$$

$$\text{Steadiness } \sigma_1 = 4.114$$

$$\sigma_2 = 4.475$$

$$\sigma_d = 2.095$$

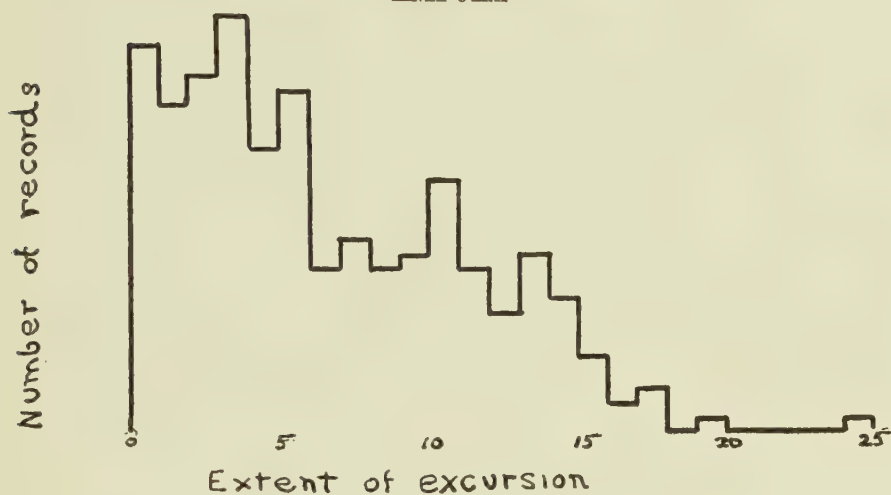
$$E = 1.482$$

$$\sigma = 4.034$$

In both cases the sigmas are very much larger than the Es.

If the average of the two tests is taken as the individual's score, the correlation between knee jerk and steadiness is found to be .299, the active knee jerk being associated with a small amount of body sway. If a correlation is made for attenuation this be-

FIGURE 3
HISTOGRAMS OF RECORDS OF 258 CHILDREN.
KNEE JERK



ROMBERG TEST

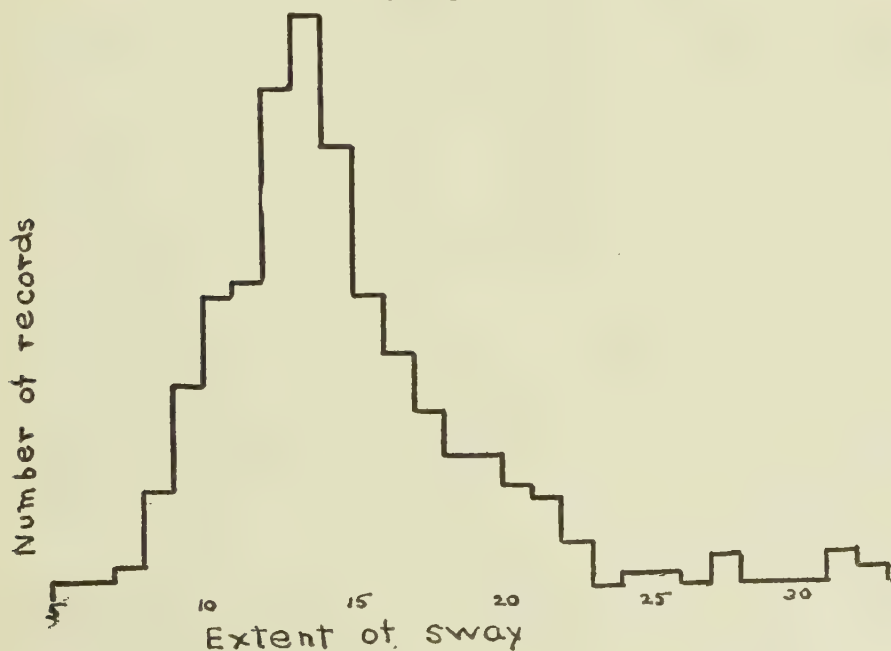
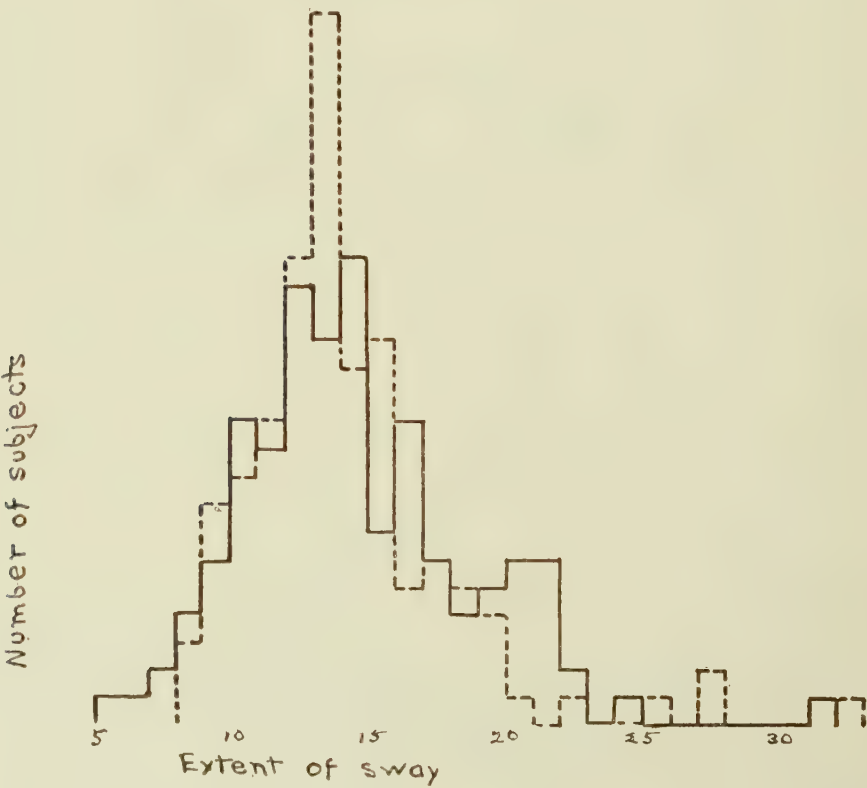
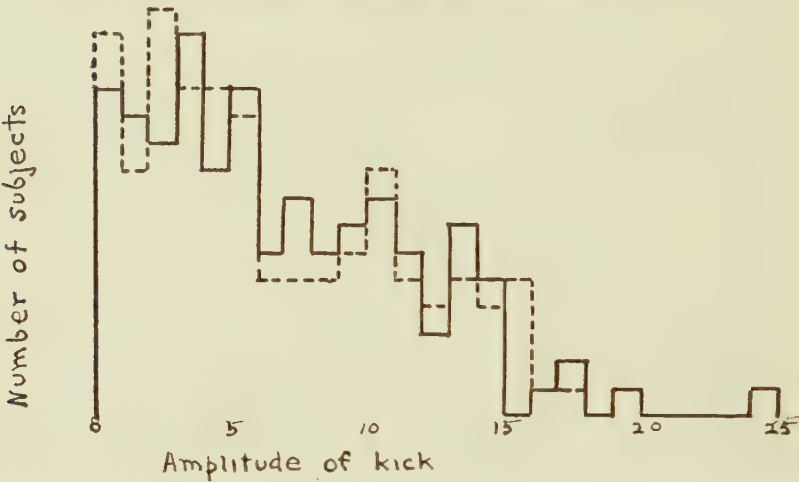


FIGURE 4
SUPERIMPOSED HISTOGRAMS OF RECORDS OF BOYS (—) AND GIRLS (---)
IN KNEE JERK AND STEADINESS.



comes .354. The correlation ratios, which are .42 and .37 are slightly higher than the Pearson coefficient, suggesting that the relation between the two functions is not linear. This may be due in part to the undistributed zeros in the knee jerk. The distribution of the scores in the two reflexes (Figure 3) shows that both are positively skewed and the knee jerk distribution is cut off at the low end. Apparently there is a distinct tendency for a low knee jerk to be associated with unsteadiness and an active knee jerk with steadiness.

The group was composed of 130 boys and 128 girls. The average knee jerk of the girls was 6.4, of the boys, 6.7. The average score of the boys in steadiness was 14.5, of the girls, 14.1. The superposition of the histograms of scores shows the absence of any considerable sex difference in our sampling of the population of children (Figure 4).

The average scores in the two tests in the four grades were as follows:

	Knee jerk	Steadiness
3rd grade	6.773	15.098
4th grade	5.897	15.006
5th grade	4.729	14.329
6th grade	8.962	13.333

Age in months of 151 of these children in the 3d, 4th and 5th grades was found to correlate negatively with knee jerk scores ($-.217$), and slightly negatively with scores indicating the amount of body sway in the Romberg test ($-.079$). The averages above indicate that a larger age range would reveal a greater relationship to steadiness and possibly a reversal in the relation to the knee jerk. It is noteworthy that the older children on the whole stand more steady than the younger in spite of their greater height and weight which of themselves, according to Fearing, are factors correlating inversely with steadiness.

The fact of individual differences being established irrespective of age or school grade and the relation of these differences to average ratings of "nervous instability" is significant only if there is some agreement between the teachers in the use and meaning of the term. The 258 children were placed in three categories, nervous (1), normal (2) and phlegmatic (3) as follows:

- 16 children were placed by all judges in class 1
- 73 children were placed by all judges in class 2
- 6 children were placed by all judges in class 3
- 76 were placed in both 1 and 2
- 56 were placed in both 2 and 3
- 31 were placed in 1, 2, and 3.

Thus we see that there was 37 per cent complete agreement, 51 per cent partial agreement and 12 per cent complete disagreement. This is considerably better than would occur by chance. The ratings of the individual teachers were then compared. There were twelve teachers, none of whom rated less than 30, or more than 70 children. The coefficient of mean square contingency was calculated between each pair of teachers who rated the same children. The values obtained ranged from .191 to .790 and the average was .495. According to Yule .816 is the maximum value obtainable when only three categories are used. If therefore a C of .816 would correspond to an r of unity, $C=.495$ may be regarded as equivalent to $r=.606$. As compared with teachers' ratings as generally reported this is a fairly good reliability, and at least indicates that the term "nervous instability" stands for a concept about which there is some social agreement, however unanalyzed it may be or badly named.

If there is an unknown x or group of x's which lend some meaning to the term, we lack at present any direct measure of it. The Matthews questionnaire should à priori be such a measure but she herself was unable to find any close relationship between her scores and any other criteria of emotional instability or neurotic tendencies.² This questionnaire was given to 151 of our children. To determine its reliability the first and last quarter of the blank were compared with the middle half. The correlation between these two partial scores was found to be .712. Corrected by Brown's formula, the reliability of the questionnaire would be .831.

TABLE II
CORRELATIONS BETWEEN VARIOUS SCORES OF 258 CHILDREN

First and second knee jerk scores.....	r=.	757 ±.02	
Reliability of the knee jerk test.....	r=.	862	
First and second steadiness scores.....	r=.	702 ±.02	
Reliability of the steadiness test.....	r=.	825	
Average coefficient of Mean Square Contingency between teachers' ratings.....	C=.	495	
which corresponds to.....	r=.	606	
Two halves of the Matthews questionnaire.....	r=.	712 ±.03	
Reliability of the questionnaire.....	r=.	831	
Age and knee jerk	r=−.	217 ±.04	
Age and Romberg test.....	r=−.	079 ±.04	
Age and questionnaire score.....	r=−.	150 ±.04	
			Age held corrected constant for atten.
Knee jerk (3) and Romberg test (4)....	r ₃₄ =−.	299 ±.03	−.299 −.354
Rating (1) and knee jerk (3).....	r ₁₃ =	.051 ±.04	.072
Rating (1) and Romberg test (4).....	r ₁₄ =−.	177 ±.04	.250
Questionnaire (2) and knee jerk (3)....	r ₂₃ =−.	146 ±.04	−.117 −.172
Questionnaire (2) and Romberg test (4).	r ₂₄ =	.216 ±.03	.297 .261
Rating (1) and questionnaire (2).....	r ₁₂ =−.	101 .05	−.142

² Matthews, J., "Emotional Instability in Children," J. of Delinquency, 1923, 8, 1-39.

TETRAD DIFFERENCES

r_{12}	r_{24}	$-r_{13}$	r_{24}	$(-.101 \times -.299) - (.052 \times .216) = .018967$
r_{12}	r_{34}	$-r_{14}$	r_{23}	$(-.101 \times -.299) - (-.177 \times -.146) = .004357$
r_{13}	r_{24}	$-r_{14}$	r_{23}	$(-.052 \times .216) - (-.177 \times -.146) = .014610$

P. E. = .013

Saturation of the knee jerk with the general factor	= .368
Saturation of the Romberg test with the general factor	= .722
Saturation of the ratings with the general factor	= .221
Saturation of the questionnaire with the general factor	= .359

If we regard the average rating given to the child as a score (the room teacher's rating being counted twice because of her greater opportunity for observation of the child), we have four independent measures, all of which might be supposed to depend upon the same unknown x . As age correlates negatively to some extent with questionnaire scores, as well as with knee jerk and unsteadiness scores, the age factor may be partialled out. The crude intercorrelations and those corrected for age and attenuation are shown in Table II. In all cases they are low but they are lowest of all between the so-called criteria. The questionnaire correlates somewhat higher than does the rating score with the knee jerk and steadiness. If we set these correlations in a tetrad equation, the tetrad differences are negligible and, if such a procedure be justifiable with such low correlations, we might argue from this that the four measures have a general factor in common, which would of course be the unknown we have called "nervous instability". If this be true and we correlate each of these four variables with the general factor, the two reflexes are shown to be more closely related to it than either the ratings or the questionnaire.

The pharyngeal reflex was absent in a larger percentage of children rated nervous than of those rated phlegmatic, and present in a larger proportion of the phlegmatic children. (Table III.)

TABLE III

THE PHARYNGEAL REFLEX IN RELATION TO RATINGS ON NERVOUS INSTABILITY

Average rating given.....	1	1 & 2	3	2 & 3	3
Number in the group.....	6	73	69	57	6
Pharyngeal reflex present.....	50%	30.1%	34.7%	42.2%	50.0%
doubtful.....	16.6	22.0	34.9	26.3	50.0
absent.....	33.4	47.9	30.4	31.5	0

CONCLUSIONS

1. True individual differences exist in the knee jerk and in the Romberg test in the organically sound population.
2. "Nervous instability" is a term in regard to the meaning of which there is considerable social agreement.
3. Ratings by adults of each other agree more closely with the

Woodworth questionnaire score than do teachers' estimates of children with the Matthews questionnaire score.

4. There is no evidence that neurotic tendencies are associated with an active knee jerk. In our sampling of adults and children there is a slight tendency in the opposite direction.

5. The neurotic adult and child tend to be more unsteady than the phlegmatic in the erect position with eyes closed.

6. The neurotic adult tends to have an active salivary reflex.

7. The pharyngeal reflex is slightly more apt to be absent in children rated nervous than in those rated normal or phlegmatic.

8. There is a low negative correlation between degree of unsteadiness and amplitude of knee jerk.

9. There is no sex difference in our sampling of school children in either the amplitude of the knee jerk or in steadiness.

10. Within the age range of the 3d, 4th and 5th grades there is a low inverse correlation between age and amplitude of the knee jerk, degree of unsteadiness, and questionnaire scores.

